U.S. FISH AND WILDLIFE SERVICE
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

SCIENTIFIC NAME: *Chamaesyce deltoidea* (Engelm. ex Chapm.) Small ssp. *serpyllum* (Small) D.G. Burch

COMMON NAME: Wedge spurge or wedge sandmat

LEAD REGION: 4

INFORMATION CURRENT AS OF: May 2010

STATUS/ACTION:
___ Species assessment - determined species did not meet the definition of endangered or threatened under the Act and, therefore, was not elevated to Candidate status
___ New candidate
_X_ Continuing candidate
___ Non-petitioned
_X_ Petitioned - Date petition received: May 11, 2004
_ 90-day positive - FR date:
_ 12-month warranted but precluded - FR date:
_ Did the petition request a reclassification of a listed species?
FOR PETITIONED CANDIDATE SPECIES:
a. Is listing warranted (if yes, see summary of threats below)? yes
b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? yes
c. If the answer to a. and b. is "yes", provide an explanation of why the action is precluded. Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for the species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The "Progress on Revising the Lists" section of the current CNOR (*http://endangered.fws.gov/*) provides information on listing actions taken during the last 12 months.

___ Listing priority change
Former LP: ___
New LP: ___

Date when the species first became a Candidate (as currently defined): October 25, 1999

___ Candidate removal: Former LP: ___
___ A - Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or

continuance of candidate status.

___U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.

___ F - Range is no longer a U.S. territory.

___ I - Insufficient information exists on biological vulnerability and threats to support listing.

___ M - Taxon mistakenly included in past notice of review.

___ N - Taxon may not meet the Act's definition of "species."

___ X - Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Flowering plants, Euphorbiaceae, Spurge Family

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Florida, U.S.A.

CURRENT STATES/ COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE: Florida, Monroe County, U.S.A.

LAND OWNERSHIP: Wedge spurge is known only from Big Pine Key in the Florida Keys. Most of the range is encompassed within the National Key Deer Refuge (NKDR). The remainder occurs on State of Florida, Monroe County, and private lands, including the Terrestris Preserve (20 acres [8 hectares{ha}]) owned by The Nature Conservancy (TNC). State and County lands are managed by the Service in a manner consistent with NKDR lands. A detailed analysis of land ownership is not available. At least 64 percent (2,891 acres [1,170 ha]) of Big Pine Key is publicly owned (NKDR, State, and County own approximately 50, 12, and 2 percent, respectively) (Lopez 2001, p. 18). The total area of pine rockland on Big Pine Key is approximately 1,433 acres (580 ha) (Lopez 2001, p. 17; Bradley and Saha 2009, p. 4). The area of publicly owned pine rockland on Big Pine Key is approximately 1,189 acres (478 ha) (Bradley and Saha 2009, p. 4) or about 82 percent of the remaining pine rockland.

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BIOLOGICAL INFORMATION:

Species Description: Wedge spurge is a small, prostrate perennial herb. The stems are slender and numerous, radiating out from the tap root. The leaves are more or less triangular. The "flowers" are cyathia, the specialized inflorescences characteristic of the genus *Euphorbia* and its close relatives. Reproduction is sexual. Some species of *Chamaesyce* are completely reliant on insects for pollination and seed production while others are self pollinating (Bradley and Gann 1999, p. 32). Pollinators may include bees, flies, ants, and wasps (Ehrenfeld 1979, p. 95-97). No studies of reproductive biology or ecology have been conducted and these topics are poorly known for *Chamaesyce* in general.

Taxonomy: John K. Small collected plants on Big Pine Key and first described *C. deltoidea* ssp. *serpyllum* as *C. serpyllum*. The taxon was later found to be related to the *C. deltoidea* complex, and subsequently ascribed to it. That complex includes several additional taxa found in the pine rockland flora of Miami-Dade County (Bradley and Gann 1999, p. 31). *Chamaesyce* is distinguished by having the main stem abortive just above the cotyledons. Synonyms include: *Chamaesyce serpyllum* Small and *Euphorbia deltoidea* Engelm. ex Chapman var. *serpyllum* (Small) Oudejans (U.S. Department of Agriculture, Natural Resources Conservation Service 2010, p. 1). We have carefully reviewed all taxonomic data to determine that *Chamaesyce deltoidea* (Engelm. ex Chapm.) Small ssp. *serpyllum* (Small) D.G. Burch is a valid taxon.

Habitat: Wedge spurge is historically known only from pine rockland vegetation on Big Pine Key (Bradley and Gann 1999, p. 31). Pine rocklands in the lower Florida Keys are dominated by a canopy of South Florida slash pine (*Pinus elliottii* var. *densa*). The subcanopy is composed of brittle thatch palm (*Thrinax morrisii*), longstalked stopper (*Psidium longipes*), poisonwood (*Metopium toxiferum*), locustberry (*Byrsonima lucida*), blackbead (*Pithecellobium keyense*), and silver palm (*Coccothrinax argentata*) (Bradley 2006, p. 25). There is also a rich herbaceous layer composed of grasses and herbs. Limestone bedrock and exposed calcareous rubble are prominent features associated with pine rockland communities (Snyder et al. 1990, p. 235–236; Ross and Ruiz 1996, p. 4). In addition to the more common associates, wedge spurge "…can grow in association with other rare taxa, including sand flax (*Linum arenicola*), and Big Pine partridge pea (*Chamaecrista lineata* var. *keyensis*)" (Bradley and Gann 1999, p. 32).

Discriminant analysis indicated that wedge spurge was associated with extensive exposed rock substrate, low total understory cover, and low hardwood density (Ross and Ruiz 1996, p. 6). Bradley and Gann (1999, p. 31) found that "plants grow directly from crevices in the oolitic limestone substrate." Bradley (2006, p. 27) found that wedge spurge exhibited "significant negative correlations with total vegetation cover ([correlation coefficient] $r_s$ = -0.144, P = 0.001), native cover ($r_s$ = -0.140, P = 0.001), hardwood cover ($r_s$ = -0.109, P = 0.012), and palm cover ($r_s$ = -0.117, P = 0.007). It had significant positive correlations with herb cover ($r_s$ = 0.158, P < 0.001) and native richness ($r_s$ = .262, P < 0.001). There were negative, but non-significant correlations with pine cover and exotic cover." The assemblage of endemic plants of the pine rockland tends to be shade intolerant and benefits from periodic burning to reduce competition from woody vegetation (e.g., shading, leaf litter accumulation) (Carlson et al. 1993, p. 922; Liu et al. 2005a, p. 210, Liu et al. 2005b, p. 71).

Pine rockland is maintained by relatively frequent fires, which maintain the understory woody plants at shrub height (Snyder et al. 1990, p. 257-263; Carlson et al. 1993, p. 915; Bergh and Wisby 1996, p. 1; Liu et al. 2005a, p. 210, Liu et al. 2005b, p. 71). In the absence of fire, many areas become wooded, eventually succeeding to rockland hammock (i.e., hardwood forest) (Snyder et al. 1990, p. 260). Alexander and Dickson (1972, p. 93) suggested that this succession process to hardwood forest may take up to 50 years in the Keys. A fundamental question about fire ecology in pine rocklands is how frequently they should burn and during what season. Snyder et al. (1990, p. 261-262) inferred the historic fire regimes on the Florida mainland by examining the time it takes for the herbaceous layer to be excluded from an area by shading (maximum time between fire) and the point where enough fuel is available to carry a fire

(minimum time since fires). The minimum fire regime found was 2-3 years and the maximum was 15 years (Snyder et al. 1990, p. 261-262). This wide range in fire frequencies would result in different forest structures and dynamics. Due to low precipitation and poor soils, the vegetation in the Keys does not grow as rapidly as it does on the mainland. Carlson et al. (1993, p. 926) suggested that a burn frequency of 5-10 years would have the greatest benefit to lower Keys pine rockland and Key deer (*Odocoileus virginianus clavium*). Liu (2003, p. 1-2) conducted detailed demographic studies of Big Pine partridge pea (a pine rockland associate of wedge spurge), and how it relates to fire. For Big Pine partridge pea, extinction probabilities were estimated to be lowest with a fire return interval of 5-8 years (Liu et al. 2005a, p. 218). Big Pine partridge pea populations declined in areas that have not burned for more than 10 years (Liu 2003, p. 137). Liu (2003, p. 139) suggested that a fire frequency of seven years would create the lowest extinction probability for Big Pine partridge pea, and that a fire regime with a wide range of burning seasons may be essential for that and the other endemic herbs of the lower Keys. Liu (2003, p. 139) indicated that fire frequency intervals of less than seven years may be detrimental, and frequencies of 10 or more years will result in population decline in the case of the pea. Although fire-return intervals have not been studied specifically for wedge spurge, it is presumed that the species' needs are similar to other pine rockland associates, such as Big Pine partridge pea.

Bradley and Saha (2009, p. 22) examined hurricane effects in relation to time since fire to assess whether differing fire regimes influence hurricane resilience or post hurricane recovery in pine rockland flora. Bradley and Saha (2009, p. 23) detected a significant positive effect of recent fires on pine rockland species richness, suggesting that a, "recently burned area is more likely to recover from the hurricane and resemble pre-hurricane species composition than an area long unburned." Bradley and Saha (2009, p. 29) concluded that fire provides for "optimal levels of canopy cover thereby allowing successful recruitment of candidate and rare species," that "fire may be an important tool in shaping the hurricane effects on candidate taxa and vegetation structure of pine rockland habitat," and that a fire regime, "should be maintained in the wake of hurricanes which eliminate the populations of candidate taxa." However, significant differences in post-hurricane recruitment among plots, relative to time since fire, were not detected in wedge spurge (Bradley and Saha 2009, p. 23). Ross and Ruiz (1999, p. 6) also found that the distribution of wedge spurge, "did not appear to be strongly related to time since fire or fire frequency."

TNC conducted burns on three experimental units in pine rockland on the Terrestris Preserve. TNC monitored wedge spurge and other rare plants annually from 1993 through 2003, and in 2006 (Slapcinsky and Gordon 2007, p. 1). From 1993 through 2003, wedge spurge on units 1 and 2 did not respond significantly to burning but remained stable overall. On unit 3, wedge spurge frequency, "showed a trend toward declining until 2001, then significantly increased two years after the 2001 burn," (Slapcinsky and Gordon 2007, p. 5). A saltwater storm surge in 2005 caused substantial declines (see below). At Terrestris Preserve, "mechanical thinning had no significant effect on rare species density or frequency," (Slapcinsky and Gordon 2007, p. 5).

Historical Range/Distribution: Wedge spurge is known only from Big Pine Key, Monroe County, Florida (Bradley and Gann 1999, p. 31). Acreage of pine rocklands on Big Pine Key

were reduced from 2,592 acres (1,049 ha) in 1955 to 1,732 acres (701 ha) in 1989 (Folk 1991, p. 188), a loss of approximately 33 percent. Subsequently, Ross and Ruiz (1996, Table 1) estimated the pine rockland area to be 1,645 acres (665.5 ha). Lopez (2001, p. 17) estimated it to be 1,433 acres (580 ha), a loss of nearly one half since 1955. This reduction in pine rockland reduced the range and distribution of the wedge spurge.

Current Range/Distribution: Wedge spurge is known only from Big Pine Key and most plants occur on NKDR. The species is present on the Terrestris Preserve (Gann et al. 2002, p. 388). Additional plants occur on unprotected, private lands, but we have no enumeration of these or other data.

Wedge spurge is not widely distributed. Ross and Ruiz (1996, p. 6) found the spurge in 32 of 145 (22 percent) circular sample plots in pine rockland. They estimated the pine rockland area of Big Pine Key to be 1,645 acres (665.5 ha). The sampling intensity of their plots represented 0.17 percent of those pine rocklands. The 145 plots were distributed along 13 linear transects. Plots with wedge spurge occurred in 8 transects. It was not found along transects in the western or southern portions of Big Pine Key. However, densities exceeded 2 plants/$m^2$ in 2 transects.

Bradley and Saha (2009, p. 1-8) conducted systematic surveys of publicly owned pine rockland (1,181 acres [478 ha]) throughout Big Pine Key to determine the population size and distribution of wedge spurge and other flora during two periods, 2005-2006 and 2007-2008 (hereafter 2005 and 2007, respectively, unless noted otherwise). The survey area included County- and State-owned parcels as well as NKDR. In 2005, during the early part of the study, a tidal surge generated by Hurricane Wilma flooded much of Big Pine Key (Bradley and Saha 2009, p. 2). This study provided the most comprehensive survey of distribution and abundance to date.

Pine rockland areas on the northern portion of Big Pine Key are less fragmented by road construction, have burned more frequently, and have less invasive exotic flora than those in the south (Bradley and Saha 2009, p. 4-5). Occurrences were not distributed uniformly within the northern portion of Big Pine Key; instead they were clustered about the higher, central portion of the island. Bradley (2006, p. 16) stated that occurrences "were mostly in a line parallel to Key Deer Blvd., far from the coastal edges of pine rockland forests." Wedge spurge was absent from most of the pine rockland. In 2005, wedge spurge was found in 8.7 percent (n = 37) of 427 plots in northern, and only 2.6 percent (n = 3) of 114 plots in southern Big Pine Key (Bradley 2006, p. 16). Occupied plots were situated at the northern edge of the southern pine rocklands, again about halfway between the east and west coasts of the island. Overall, wedge spurge was detected within 7.4 percent (n = 40) of 541 plots in 2005 (Bradley (2006, p. 11). Bradley (2006, p. 21) placed additional plots (n = 128) along portions of major trunk roads (Key Deer Boulevard and Wilder Road) that intersect pine rockland on Big Pine Key. Wedge spurge was found in 8 (6.3 percent) of the roadside plots. The 8 occupied plots were limited to northern Big Pine Key.

Frequency of occurrence declined significantly between 2005 and 2007. In the 297 pine rockland plots that were initially sampled before Hurricane Wilma, frequency of occurrence declined 40 percent (10 and 6 percent of plots were occupied by wedge spurge in 2005 and 2007, respectively) (Bradley and Saha 2009, p. 12). In both 2005 and 2007, the frequency of

occurrence in plots was significantly higher in northern than the southern pine rocklands (Bradley and Saha 2009, p. 9). Wedge spurge was recorded in 10 and 7 percent of all plots in northern pine rocklands in 2005 and 2007, respectively. Frequency of occurrence in southern pine rocklands was 9 and 0 percent in 2005 and 2007, respectively (Bradley and Saha 2009, p. 9-10).

In 2007 and 2008, Bradley and Saha (2009, p. 4) expanded the area of systematic surveys to include publicly owned pine rockland throughout Cudjoe Key (178 acres [72 ha]), Little Pine Key (131 acres [53 ha]), No Name Key (138 acres [56 ha]), and Sugarloaf Key (94 acres [38 ha]). Consistent with its historical range, wedge spurge was not found in these study plots.

Population Estimates/Status: Total population size throughout the Big Pine Key pine rockland study area (1,181 acres [478 ha]) was estimated to be 289,051 to 653,265 in 2005 (pre-Hurricane Wilma, 297 plots) and 101,091 to 340,476 in 2007 (post-Wilma, 285 plots) (Bradley and Saha 2009, p. 12). Since 82 percent of the pine rockland on Big Pine Key is publicly owned, this estimate likely accounts for the majority of the population. Wedge spurge density and percent cover was significantly higher in 2005 compared to 2007, in all plots combined as well as separately for northern and southern plots. In 2005, a total of 686 plants were counted in 297 plots, whereas in 2007 only 568 plants were counted in 285 plots (Bradley and Saha 2009, p. 12). Mean density was 2.30 plants per plot in 2005 and 1.99 plants per plot in 2007 (Bradley and Saha 2009, p. 12). In both 2005 and 2007, the density was significantly higher in northern (2.46 and 2.11 plants per plot, pre- and post-Wilma, respectively) than southern (0.96 and 0.93 plants per plot, pre- and post-Wilma, respectively) pine rocklands (Bradley and Saha 2009, p. 10). Accordingly, the frequency of occurrence of wedge spurge in plots sampled after the storm was less than half the frequency encountered in plots sampled prior to the storm. Stages or size distributions of the plants were not assessed (the estimates include plants in all life stages beyond seed).

On the Terrestris Preserve, monitoring was conducted annually from 1993 through 2003, and in 2006 (Slapcinsky and Gordon 2007, p. 1). The mean frequency of wedge spurge occurrence among plots changed from 9.7 to 9.9 in unit 1 (1993-2003), 3.7 to 8.9 in unit 2 (1994-2003) and 14.0 to 7.2 in unit 3 (1993-2002). In 2006, subsequent to Hurricane Wilma, values for units 1, 2, and 3 were 0.28, 0.13, and 0.27, respectively. Density and frequency of all four of the rare, focal plant species in that study showed "serious declines" on all three study units in 2006, which was likely due to Hurricane Wilma (Slapcinsky and Gordon 2007, p. 6).
The species was not found during a two-year project intended to survey and map exotic and rare plants along Florida Department of Transportation (FDOT) right-of-ways within Monroe County (Gordon et al. 2007, p. 1, 36).

THREATS:

A. The present or threatened destruction, modification, or curtailment of its habitat or range. Nearly one half of the wedge spurge habitat has been lost to development. Studies have shown more than 50 percent reduction in habitat for the wedge spurge from 2,592 acres (1,049 ha) in 1955 to 1,433 acres (580 ha) in 2000 (Folk 1991, p. 188; Lopez 2001, p. 17).

This trend of habitat development, while a major historical factor, is now greatly reduced. Change in percent human population for Monroe County from April 1, 2000 to July 1, 2008 was -9.2 percent (http://quickfacts.census.gov). Most pine rockland habitat on Big Pine Key is now owned by conservation agencies.

A Habitat Conservation Plan (HCP) for the Key deer and other listed species limits development mainly to previously cleared lands on Big Pine and No Name Keys (Monroe County et al. 2006, p. 4). Under this HCP, no more than 168 acres (68 ha) can be developed over 20 years, and of this no more than 7 acres (2.8 ha) will be native habitat. Although the HCP focuses on the Key deer, Lower Keys marsh rabbit (*Sylvilagus palustris hefneri*), and eastern indigo snake (*Drymarchon corais couperi*), the plan will benefit wedge spurge by greatly limiting development in pine rockland habitat within the majority of its current range on Big Pine Key. The Incidental Take Permit for the HCP will expire in 2014.

Climatic changes and sea level rise are major threats to south Florida, including this species and its habitat. The Intergovernmental Panel on Climate Change (IPCC) reported that the warming of the world's climate system is unequivocal based on documented increases in global average air and ocean temperatures, unprecedented melting of snow and ice, and rising average sea level (IPCC 2007, p. 2; 2008, p. 15). Sea-level rise is the largest climate-driven challenge to low-lying coastal areas and refuges in the sub-tropical ecoregion of southern Florida (U.S. Climate Change Science Program [CCSP] 2008, p. 5-31, 5-32). The long-term record at Key West shows that sea level rose on average 0.088 inches (0.224 cm) annually between 1913 and 2006 (National Oceanographic and Atmospheric Administration [NOAA] 2008, p. 1). This equates to approximately 8.76 inches (22.3 cm) over the last 100 years (NOAA 2008, p. 1).

IPCC (2008, p. 28) emphasized it is very likely that the average rate of sea-level rise during the 21st century will exceed that from 1961 to 2003 (i.e., 0.071 inches [0.18 cm] per year), although it was projected to have substantial geographical variability. Partial loss of the Greenland and/or Antarctic ice sheets could result in many feet (several meters) of sea-level rise, major changes in coastlines, and inundation of low-lying areas (IPCC 2008, p. 28-29). Low lying islands and river deltas will incur the largest impacts (IPCC 2008, p. 28-29). Because dynamic ice flow processes in ice sheets are poorly understood, timeframes are not known; however, modeling indicates that "more rapid sea-level rise on century timescales cannot be excluded" (IPCC 2008, p. 29). According to CCSP (2008, p. 5-31), much of low-lying, coastal south Florida "will be underwater or inundated with salt water in the coming century."

IPCC (2008, p. 3, 103) concluded that "climate change is likely to increase the occurrence of saltwater intrusion into coastal aquifers as sea level rises" and that "sea-level rise is projected to extend areas of salinisation of groundwater and estuaries, resulting in a decrease of freshwater availability for humans and ecosystems in coastal areas." From the 1930s to 1950s, increased salinity of coastal waters contributed to the decline of cabbage palm forests in southwest Florida (Williams et al. 1999, p. 2056-2059), expansion of mangroves into adjacent marshes in the Everglades (Ross et al. 2000, p. 9, 12-13), and loss of pine rockland

in the Keys (Ross et al. 1994, p. 144, 151-155). Hydrology has a strong influence on plant distribution in these and other coastal areas (IPCC 2008, p. 57). Such communities typically grade from salt to brackish to freshwater species. In the Keys, not only are elevation differences between such communities very slight (Ross et al. 1994, p. 146), but the horizontal distances are small as well. Human developments will also likely be significant factors influencing whether natural communities can move and persist (IPCC 2008, p. 57; CCSP 2008, p. 7-6).

Sea level rise is a significant threat to the species and its habitat. There has been a 15 centimeter (5.9 inch) rise in sea level over a 70-year period in the vicinity of Big Pine Key (Ross et al. 1994, p. 145). The pine rockland community in the Keys has undergone a reduction due to sea level rise (Ross et al. 1994, p. 149). For example, the pine rockland area on Sugarloaf Key covered 217 acres (88 ha) prior to 1935, and was reduced to 114 acres (46 ha) by 1935 and 74 acres (30 ha) by 1991 (Ross et al. 1994, p. 149). The loss of pine rockland communities and upland plant diversity was correlated with elevated ground- and soil-water salinity (Ross et al. 1994, p. 150-151). In areas affected by sea level rise, communities of halophytic plants replaced pine rockland communities (Ross et al. 1994, p. 152). Based on IPCC and other predictions of sea level rise, Clough (2008, p. 23) concluded that a significant proportion of upland habitat will be lost on Big Pine Key by 2100.

TNC (2010, p. 1) used high-resolution digital elevation models derived from highly accurate Light Detection and Ranging (LIDAR) remote sensing technology to predict future shorelines and distribution of habitat types for Big Pine Key based on sea level rise predictions ranging from the best-case to worst-case scenarios described in current scientific literature. In the Florida Keys, TNC models predicted that sea level rise will first result in the conversion of habitat, and eventually the complete inundation of habitat. In the best-case scenario, a rise of 7 inches (18 cm) would result in the inundation of 1,840 acres (745 ha) (34 percent) of Big Pine Key and the loss of 11 percent of the island's upland habitat (TNC 2010, p. 1). In the worst-case scenario, a rise of 4.6 feet (140 cm) would result in the inundation of about 5,950 acres (2,409 ha) (96 percent) and the loss of all upland habitat (TNC 2010, p. 1).

Similarly, using a spatially explicit model for the Keys, Ross et al. (2009, p. 473) found that mangrove habitats will expand steadily at the expense of upland and traditional habitats as sea level rises. Most of the upland and transitional habitat in the central portion of Sugarloaf Key is projected to be lost with a 0.2 m-rise (0.7 ft-rise) in sea level; a 0.5-m rise (1.6 ft-rise) in sea level can result in a 95 percent loss of upland habitat by 2100 (Ross et al. 2009, 473). Furthermore, Ross et al. (2009, p. 471-478) suggest that interactions between sea-level rise and pulse disturbances (e.g., storm surges or fire [see Factor E]) can cause vegetation to change sooner than projected based on sea level alone.

At present, fire suppression may be one of the greatest threats to wedge spurge. While fires may have occurred at least once per decade in the past, the fire frequency since about 1950 has been sharply reduced throughout the island, despite occasional prescribed burns conducted by the Service and TNC (Bergh and Wisby 1996, p. 1). While fire suppression has occurred mostly adjacent to developed areas, all pine rockland areas on Big Pine Key

have suffered from lack of fire, including pine rockland within the NKDR. Because of this drop in burn frequency, habitat characteristics have changed. For example, Alexander and Dickson (1972, p. 90) indicated that brittle thatch palm densities tripled from 1951-1952 to 1969-1970. Historical photographs of Big Pine Key show a very open understory (e.g., Figure 1 in Alexander and Dickson 1972, p. 89); however, the understory across much of Big Pine Key now consists of dense and tall thatch palms. Bradley (2006, p. 27) found a negative correlation between wedge spurge and native vegetation cover, hardwood cover, palm cover, and total cover, indicating that vegetation changes associated with a reduced fire frequency are detrimental to wedge spurge. Carlson et al. (1993, p. 914) reported similar findings for endemic plants on Big Pine Key.

Fire is required to maintain the pine rockland community (Snyder et al. 1990, p. 257-263; Carlson et al. 1993, p. 915; Bergh and Wisby 1996, p. 1; Liu et al. 2005a, p. 210; Liu et al. 2005b, p. 71). With fire suppression, hardwoods eventually invade pine rocklands and shade out understory species like wedge spurge. Fire suppression reduces the size of the areas that burn, and habitat fragmentation prevents fire from moving across the landscape. Accordingly, in the absence of fire, pine rockland communities tend toward becoming tropical hardwood hammock communities. In many areas, pine rockland communities have been succeeded by tropical hardwood hammock flora. The details of these shifts have not been quantified and monitored over extensive portions of the pine rockland. NKDR is attempting to address these problems; however, 50+ years of fire suppression has caused changes in pine rockland community structure that are going to be very difficult to reverse. In 2003, NKDR burned a 120-acre (48.6-ha) site on Big Pine Key that had been unburned for 17 years; this was the largest NKDR burn in recent years. Of 318 pine rockland plots that were initially assessed on Big Pine Key in 2005, 110 were not burned, 77 were burned once, 55 were burned twice, and 76 were burned either three or four times since 1960 (Bradley and Saha 2009, p. 22).

Two burns totaling 10 acres (4 ha) were burned on NKDR in 2009 (A. Morkill, pers. comm. 2010). NKDR is assessing rare plant response to 2009 prescribed burns, including the response of wedge spurge (Anderson 2010, slide 18). In study plots, 393 plants were found before the burn was implemented; this was reduced to 177 plants 2 months post-fire and 281 plants 4 months post-fire (Anderson 2010, slide 18). Additional post-fire monitoring should help clarify long-term responses.

Slapcinsky et al. (2010, p. 4-10) examined the fire responses of 18 rare plant species from 14 families occurring on sandhill, scrub, pine rockland, and mixed deciduous hardwood communities in Florida to better understand the likely negative impacts of fire suppression. Across all species and life history traits, variables for 9 of the 18 species (50 percent) showed statistically significant positive responses to fire, and variables for 9 species (50 percent) showed neutral responses; no species showed a significantly negative response to fire (Slapcinsky et al. 2010, p. 11). None of the species studied were unable to recover post-burn (Slapcinsky et al. 2010, p. 4). Wedge spurge showed statistically significant frequency dependence on time since fire (Slapcinsky et al. 2010, p. 11). Slapcinsky et al. (2010, p. 16) suggest that the duration of monitoring might be insufficient to fully clarify patterns of

responses to fire. In general, Slapcinsky et al. (2010, p. 4) argue that prescribed fire in pyrogenic habitats should not be delayed until species-specific responses to fire are understood.

Complete implementation of a prescribed fire program in the lower Keys has been hampered by an incomplete understanding of the fire ecology in the area, and by public opposition to burning. To address ecological aspects of burning, several research studies have been conducted. For 10 years at the Terrestris Preserve, TNC has been conducting relatively frequent, growing season prescribed fires, experimental mechanical pre-fire fuel treatments, and ongoing monitoring to quantify the effects of these efforts on community structure and rare plants (Slapcinsky and Gordon 2007, p. 1). The Service is working cooperatively with Florida International University in Miami to determine the proper fire frequencies necessary to maintain the pine rockland community on NKDR (Snyder et al. 2005, p. iv - v). In areas where fires have been suppressed for many years, the reintroduction of fire may have to be done in a step-wise fashion. In some areas it may include winter burns, or removal of some fuel to prevent a hot fire. Any prescribed fire management should include a monitoring program to determine the effectiveness of the prescription.

Public perception of prescribed burning is widely variable across the United States (Manfredo et al. 1990, p. 20-22). This is no exception in the lower Keys, where many residents are strongly opposed to the use of prescribed fire. This opposition has limited the ability of NKDR to conduct burns as frequently as needed. Complicating the issue is that many homes on Big Pine Key and other islands have been built in a mosaic of pine rockland, so the use of prescribed fire in many places has become complicated because of potential danger to structures.

In summary, wedge spurge has been impacted by loss of pine rocklands. Although most remaining habitat is protected on public lands, wedge spurge is threatened by climate change and sea-level rise, which are major, long-term threats that will be difficult to address. Fire suppression and general lack of prescribed fire, which results in the loss and degradation of habitat, is also a significant threat. Overall, the magnitude of threats is moderate.

B. Overutilization for commercial, recreational, scientific, or educational purposes. None known.

C. Disease or predation. None known.

D. The inadequacy of existing regulatory mechanisms. The Florida Department of Agriculture and Consumer Services designated *C. deltoidea*, which includes ssp. *serpyllum* as endangered under Chapter 5B-40, Florida Administrative Code. This listing regulates take without permission of the landowner. It provides little or no habitat protection beyond the State's Development of Regional Impact process, which discloses impacts from projects, but does not provide regulatory protection for plants on private lands.

Monroe County requires mitigation for impacts to rare plant species. If wedge spurge is

found on a property that is to be developed, the property owner would be required to pay a mitigation fee to the County prior to development. This process allows for the loss of individual plants and habitat and does not fully protect the species or its habitat. Due to land ownership patterns and the Big Pine and No Name Keys HCP, the imminence and magnitude of this threat is relatively low. However, pressure to develop more of Big Pine Key continues, and the Incidental Take Permit for the HCP will expire in 2014.

E. Other natural or manmade factors affecting its continued existence. The small area, few occurrences, and somewhat patchy distribution of wedge spurge renders it susceptible to extinction risks associated with stochastic demographic, genetic, and environmental events, including catastrophic storms. Further reduction of population size would likely enhance threats associated with genetics and demographic stochasticity (Caughley 1994, p. 217).

Exotic plants have detrimental impacts on pine rocklands. At least 277 taxa of exotic plants are now known from pine rocklands in south Florida (Service 1999, p. 3-175). Bradley (2006, p. 25-26) found that 12.1 percent of pine rockland plots on Big Pine Key had exotic plants, recording 16 exotic plant taxa in study plots. Some of these are a threat to wedge spurge because they alter community structure and composition or even form dense monocultures in habitats otherwise used by wedge spurge. The most frequent exotic plant species recorded were Brazilian pepper (*Schinus terebinthifolius*), hurricane sedge (*Fimbristylis cymosa*), West Indian mahogany[1] (*Swietenia mahagoni*), and St. Augustine grass (*Stenotaphrum secundatum*) (Bradley 2006, p. 25-26). Australian pine (*Casuarina equisetifolia*), earleaf acacia (*Acacia auriculiformis*), natal grass (*Rhynchelytrum repens*), shrub verbena (*Lantana camara*), woman's tongue tree (*Albizia lebbeck*), and bracken fern (*Pteridium aquilinum* var. *caudatum*) are some of the other exotic species that invade pine rocklands and edge habitats that are otherwise suitable for wedge spurge. Some of these may compete directly with wedge spurge for space and resources, while others have a profound effect on community structure and responses to fire. When habitats are infested by invasive exotics, lack of control (particularly if in conjunction with fire suppression) may result in dense foliage and high fuel loads. If left uncontrolled in a fire-suppressed pineland, invasive species such as Brazilian pepper may form a dense monospecific canopy almost completely eliminating native vegetation. They will also affect the characteristics of a fire when it occurs, and or the structure and composition of plant communities after fire occurs. This results in additional threats to wedge spurge. Where exotic plants are present, the known benefits of prescribed fire for wedge spurge are less certain to occur. When there are fires in infested areas, instead of being relatively cool fires that consume light fuels (e.g., pine needle litter) as in the past, they may burn much hotter and have detrimental effects on the vegetation that develops following fire. For instance, under some post-fire circumstances, dense bracken fern thickets develop (Ross and Ruiz 1996, p. 4). Bradley (2006, p. 2), who has done the vast majority of recent work on wedge spurge, Big Pine partridge pea, and sand flax stated: "Long-term ecological changes on the island associated with fire suppression, land clearing, sea level rise, changes in hydrology, fluxes in Key Deer densities, and invasion

1 West Indian mahogany is native to a limited area of Florida. Its natural range does not include Big Pine Key, where it has been introduced for landscaping and has since escaped into pine rocklands

of exotic pest plants may have had and will continue to have impacts on the population sizes of these three taxa."

In a recent study to better understand the location and extent of invasive exotic plants and rare native plants along roadways in Miami-Dade and Monroe Counties, 88 of 121 (73 percent) total target exotic plant species were found in at least one road segment (Gorden et al. 2007, p. 10). Of the 16,412 road segments surveyed, 6,264 (38 percent) contained at least one exotic plant species; some segments contained more than one species of invasive exotic plant (and as many as 15) (Gordon et al. 2007, p. 10-11). In Monroe County, the most frequent invasive exotic plants recorded were Brazilian-pepper, white leadtree (*Leucaena leucocephala*) and punctureweed (Gordon et al. 2007, p. 11). Because pine rockland habitat in Monroe County is being impacted by exotic plant species, which alter fire behavior and compete with native species for sunlight and nutrients, the wedge spurge is also threatened by the invasion of these non-native plants.

Hurricanes and tropical storms are an additional threat, particularly to the extent that they yield storm surges with salt-water overwash. Hurricane storm surges can inundate landscapes with saltwater for varying durations. Klimstra (1986, p. 3) stated "The effects of salt water on pinelands is well established as a consequence of hurricane Betsy, September 8, 1965. After 20 years the site where waters were entrapped for several hours has not yet fully recovered from complete loss of *Pinus, Ernodea, Randia, Pisonia,* and *Metopium* seedlings." The small area of occupancy and somewhat patchy distribution of wedge spurge renders it susceptible to extinction through such stochastic events. In 2005, Hurricane Wilma resulted in a storm surge that covered most of Big Pine Key with seawater.

In plots that were sampled prior to the passage of Hurricane Wilma, wedge spurge was found in 9.3 percent (n = 31) of 332 plots surveyed (in 2005) prior to the storm and 4.3 percent (n = 9) of 209 plots surveyed (in 2006) after the storm (Bradley 2006, p. 16). Density decreased from 1.7 ± 8.9 plants per plot to 1.0 ± 6.5 plants per plot before and after the storm, respectively. This decrease was significant ($U$ = 32,978.5, $P$ = 0.027). Multi-year decline was not as drastic. Mean density in the entire pine rockland habitat of Big Pine Key was 2.30 plants per plot in 2005 and 1.99 plants per plot in 2007 (Bradley and Saha 2009, p. 12). On the Terrestris Preserve, density and frequency of all four rare, focal plant species, including wedge spurge, showed "serious declines" on all three burn units in 2006, which was likely due to Hurricane Wilma (Slapcinsky and Gordon 2007, p. 6).

Hurricane Wilma negatively impacted both species richness and diversity of pine rockland flora, with significant declines in both northern and southern Big Pine Key (Bradley and Saha 2009, p. 15). The storm surge associated with Hurricane Wilma had a direct negative impact on wedge spurge and herbaceous species density and cover in general (Bradley and Saha 2009, p. 27). The percent cover of graminoids (i.e., true grasses, sedges and rushes) herbaceous species, and slash pine declined significantly after Hurricane Wilma (Bradley and Saha 2009, p. 15). In contrast, the percent cover of palms and hardwoods, particularly thatch palm and buttonwood (*Conocarpus erectus*) increased significantly between 2005 and 2007 (Bradley and Saha 2009, p. 15). Accordingly, hurricanes do not hinder the successional

advances that result from limited fires, and may exacerbate them. The long term impacts of this hurricane are uncertain. There may be synergistic effects with fire and exotics. However, slash pine needle-fall (litter) appears to provide for fire advancement in pine rockland communities. Because large areas of slash pine are dead and may remain so, fire may no longer occur and provide important functions that enable the persistence of wedge spurge and other flora within these communities.

Bradley and Saha (2009, p. 26) found that candidate plants in pine rockland were restricted to sites in which ground elevation was greater than 0.5 m (1.6 feet). Wedge spurge densities were significantly, positively correlated with elevation (Bradley and Saha 2009, p. 26). Bradley and Saha (2009, p. 27) found that: "In the southern plots which harbor disturbed and low-lying pinelands, *Chamaesyce deltoidea* was wiped out." However, compared to Big Pine partridge pea, wedge spurge showed a less drastic overall decline subsequent to Hurricane Wilma, because it was already more restricted to "the highest elevation on the pine rockland habitat in the northern plots that were less prone to flooding," (Bradley and Saha 2009, p. 27). Bradley and Saha (2009, p. 30) concluded that "increased hurricane frequency may have a devastating impact on candidate plant taxa and on species composition in pine rocklands of the lower Florida Keys." Sea level rise will exacerbate effects of hurricanes on these plants.

In addition, Bradley (2006, p. 36) alluded to two additional potential factors that may be causing a decline in wedge spurge density and abundance. Liu and Koptur (2003, p. 1186) found that aerial mosquito spraying may exacerbate the existing pollinator limitation suffered by Big Pine partridge pea (*Chamaecrista lineata* var. *keyensis*) (a candidate) by reducing the number of visits by the buzz-pollinating bees. Pesticide spraying is common on Big Pine Key and its suppression of pollinator populations may also have a long-term impact on reproduction rates of wedge spurge (Bradley 2006, p. 36). However, the lack of pollinator information for wedge spurge makes assessing the affects of mosquito spraying in the Keys on this species difficult if not impossible. Liu and Koptur (2003, p. 1184) also found that Big Pine partridge pea individuals at urban edges produced fewer seeds per fruit than did individuals in a pristine forest mainly because of greater insect seed predation. Bradley (2006, p. 36) suggested that similar problems with forest fragmentation and proximity to homes and business may also be impacting wedge spurge.

In summary, exotic plants are a threat, which is reduced through active management. The small area of occupancy and patchy distribution of wedge spurge place it at risk to stochastic events. Tropical storms and hurricanes are continuing threats, and continue to be exacerbated by climate change including sea level rise. Pesticide application to control mosquitoes may be a threat to wedge spurge through limitation of pollinators. Forest fragmentation may also be a problem. Overall, the magnitude of threats is moderate.

CONSERVATION MEASURES PLANNED OR IMPLEMENTED: Most of the remaining population is protected from development due to its presence on conservation lands owned by the Service, State, County, or TNC. An HCP for listed species (Monroe County et al. 2006, p. 1-81) has been completed. This plan benefits wedge spurge because of its provisions for habitat

protection. This plan limits development mainly to previously cleared lands within a significant portion of the wedge spurge's current range. Under the provisions of the HCP, no more than 168 acres (68 ha) will be allowed to be developed over the 20-year term of the plan, and of this no more than 7 acres (2.8 ha) will be native habitat.

The Service conducts occasional prescribed fires in much of the pinelands under its jurisdiction. Additionally, habitat degradation due to lack of fire in the pinelands is being addressed through the lower Keys Wildland Fire Hazard Reduction Initiative. In addition to the Service, this informal consortium includes TNC and State agencies, all of which address prescribed fire planning and execution cooperatively. The Service is working cooperatively with Florida International University, TNC, and others to determine optimal ranges of fire frequencies necessary to maintain the pine rockland community on NKDR. The Service is working with partners to develop and implement effective practices to monitor the effects of fire and better quantify the effects of past fire suppression. However, few prescribed fires have been conducted on Big Pine Key in recent years.

The NKDR uses mechanical treatments sparingly, largely to control hardwoods for fire breaks and to reduce fuels loads, around houses adjoining properties managed by the Service. Several fire breaks were restored or created on Big Pine Key in 2006. The Service partnered with The Institute of Regional Conservation (IRC) to assess the effects of the fire breaks on wedge spurge. This study is not yet complete.

The Service's National Wildlife Refuge System and Private Stewardship Grant Program and TNC maintain active programs to control invasive exotic plants in pine rocklands, particularly on conservation properties such as NKDR. The Service's Coastal program provided $100,000 for a two-year project that will help restore pine rocklands in the Keys (D. DeVore, pers. comm. 2010). The Partners for Fish and Wildlife program is also supporting similar habitat restoration projects in the Keys.

The FDOT collaborated on and funded a study of the approximately 650 miles of FDOT roadway in Miami-Dade and Monroe counties (District 6) (Gordon et al. 2007, p. 1, 3). The study was conducted by The University of Florida, in collaboration with IRC and the FNAI to survey and map exotic and rare native plants along FDOT right-of-ways within Miami-Dade and Monroe counties and to create a database that can be updated to reflect future activities and conditions (Gordon et al. 2007, p. 1, 3).

SUMMARY OF THREATS: The wedge spurge is a narrow endemic. Its rarity has increased due to long-term human influences. About half of the pine rockland habitat of the wedge spurge has been lost due to development. Based on long-term trends, development pressures are expected to continue in the future. However, the rate of development, and the magnitude of development related threats, has significantly declined within the range of the wedge spurge. Climatic changes and sea level rise are long-term threats that will continue; these factors are expected to continue to impact pine rocklands and ultimately, substantially reduce the extent of available habitat, especially in the Keys. Clough (2008, p. 23) predicts that, even under the best of circumstances, a significant proportion of upland habitat will be lost on Big Pine Key by 2100.

This will severely impact the viability of wedge spurge, probably limiting it to the highest elevations in small portions of Big Pine Key. Wedge spurge is also threatened by fire suppression, hurricanes, and to a lesser degree, exotic plants. The small geographic range of the taxon exacerbates these threats. Storm surges associated with hurricanes are the most imminent of the stochastic threats. This is evident from the tidal surge generated by Hurricane Wilma in 2005 that flooded much of the habitat for wedge spurge and significantly reduced its distribution and abundance. Fire suppression is the most imminent of the deterministic threats. Absence of fire constitutes a habitat disturbance for wedge spurge and threatens the probability of its persistence. It is likely that wedge spurge's probability of persistence can increase if the use of prescribed fire increases. Populations can be salvaged with the return or advent of fire management, unless confounded by invasive plants, which is unlikely due to active exotics control on NKDR. At present, Brazilian pepper is largely under control in intact pine rockland on NKDR lands and the Terrestris Preserve, and other exotics do not constitute threats of high imminence or magnitude. The magnitude and imminence of threats from fire suppression and invasive exotic plants are somewhat greater on lands in the private sector as opposed to sites in conservation status. Even if the above issues are successfully addressed, the threat of sea level rise remains. Reduced pollinator activity and suppression of pollinator populations from pesticides used in mosquito control may have a long-term impact on reproduction rates for this species (Bradley 2006, p. 36). The effects of forest fragmentation may also be a problem (Bradley 2006, p. 36). We find that this species is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

RECOMMENDED CONSERVATION MEASURES

- The largest benefits to this taxon would be accomplished with an increase in prescribed fires. Prescribed fires should be conducted across all pine rockland areas in NKDR and other portions of Big Pine Key. NKDR has revised its Comprehensive Conservation Plan; this plan calls for a revised Fire Management Plan. Those plans should be completed and executed as soon as feasible.
- Mechanical treatments can be effective in preparing for prescribed fires. These techniques will probably be most beneficial in pine rockland areas that have undergone long periods of fire suppression. There are many such areas in the southern half of Big Pine Key. Such areas would probably benefit from mechanical understory removal treatments prior to prescribed fires.
- Conduct further research into fuel reduction and fire-wedge spurge interactions, including the effects of mechanical treatments.
- Actions such as fire break establishment and maintenance may potentially benefit wedge spurge, but effects need to be quantified before the outcome is determined.
- Given the large impact of Hurricane Wilma, monitor wedge spurge and community characteristics that are positively correlated with wedge spurge occurrences on multiple spatial scales.
- The Service and other agencies should continue exotic plant control programs in pine rockland habitat. Exotic plant densities in most pine rockland areas on Big Pine Key are currently low, and management should continue to prevent spread of invasive exotic plants.

- NKDR should institute an integrated program of adaptive management in order to prioritize and optimize efforts and objectives pertaining to pine rockland viability, fire regimes, and fuel reduction relative to wedge spurge and other endemic plants.
- Develop sea level rise and hurricane impact models, and encourage the integration of these models in management efforts in order to enhance their effectiveness.
- Consider the need to establish and maintain an *ex situ* collection of wedge spurge in the future to reduce its vulnerability to catastrophic events, if the trend in population continues to decline.

LISTING PRIORITY

| THREAT | | | |
|---|---|---|---|
| Magnitude | Immediacy | Taxonomy | Priority |
| High | Imminent | Monotypic genus | 1 |
| | | Species | 2 |
| | | Subspecies/population | 3 |
| | Non-imminent | Monotypic genus | 4 |
| | | Species | 5 |
| | | Subspecies/population | 6 |
| **Moderate to Low** | **Imminent** | Monotypic genus | 7 |
| | | Species | 8 |
| | | **Subspecies/population** | **9*** |
| | Non-imminent | Monotypic genus | 10 |
| | | Species | 11 |
| | | Subspecies/population | 12 |

Rationale for listing priority number:

*Magnitude*: Wedge spurge exists essentially as a single, patchy population on Big Pine Key, which over the long run is substantially protected and managed only on NKDR and the Terrestris Preserve. This narrow range makes wedge spurge particularly susceptible to several threats. Climatic changes and sea level rise are long-term threats that will reduce the extent of habitat. Over the long-term, sea level rise is expected to become a major threat which will be difficult to address. Population size was reduced sharply by Hurricane Wilma, and we know little about its capacity to recover. In the absence of a fairly rapid rebound, further storm surges could add to the impacts. Regardless, threats from hurricane storm surges are exacerbated by sea level rise. Reduced pollinator activity and suppression of pollinator populations from pesticides used in mosquito control and decreased seed production due to increased seed predation in a fragmented landscape may also affect wedge spurge; however, not enough information is known on this species' reproductive biology or life history to assess these potential threats. The effects of forest fragmentation may also be a problem. At this time, we believe that a narrow distribution, combined with fire suppression, hurricane storm surges, and sea level rise, make for an overall

magnitude of threat of moderate.

*Imminence*: The best available information indicates that this plant is intrinsically vulnerable to extinction because it is a narrow endemic. Much of the species' range now resides within the NKDR or lands managed by the Service, so the imminence of development-related threats is relatively low at present. Exotic plants are currently being controlled through management, particularly on conservation lands on which the majority of the wedge spurge's range is found. Accordingly, threats from invasive exotic plants are non-imminent, at present. At this time, the immediacy of threats are primarily related to adequacy and effectiveness of prescribed fire in pine rocklands, the severity of impacts from hurricane storm surges, and rate of sea level rise. Some fire management is being accomplished, but at a much slower rate than is required, and only in some parts of the wedge spurge's range. If the frequency of prescribed fire does not increase, threats associated with low fire return intervals will continue to increase. We consider fire-related threats to be imminent. Sea level rise is a major long-term historical, current, and future threat that is resulting in the loss of pine rocklands. This threat is currently occurring and will increase over time. The wedge spurge was severely impacted over the majority of its range by a storm surge in 2005; the probability of intense hurricanes has increased in recent years, and increasing sea levels exacerbate threats from hurricanes, storm surges in particular. This threat is imminent and exacerbated by climate change and sea level rise. Overall, we consider the threats to be imminent; the most consequential threats (hurricanes, storm surges) are frequent, recurrent, and imminent.

Yes Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed?

Is Emergency Listing Warranted? No. On NKDR, application of prescribed fire could be increased significantly, with commensurate benefits to wedge spurge. Control of invasive exotic plants has progressed in recent years to the extent that expansion has been greatly limited. The rate of development in remaining wedge spurge habitat has been reduced substantially.

DESCRIPTION OF MONITORING: The Service has conducted extensive literature searches and obtained all recent and most historical documents pertaining to wedge spurge. The Service developed and funded a project (Bradley 2006, p. 1-41; Bradley and Saha 2009, p. 1-31) to comprehensively assess pine rockland flora (including wedge spurge abundance) on NKDR and other conservation lands throughout the Lower Keys. The survey framework derived from this study will allow for monitoring of trends and threats over time, if funding are provided periodically. The Service is collaborating with TNC and IRC to assemble, reconstruct, and render on GIS all known wildland fire histories for the lower Keys, including the prescribed fires on and adjacent to NKDR in recent years (Bradley and Saha 2009, p. 1-31). We are attempting to ensure that the fire history distribution is appropriately incorporated into the sampling scheme of future inventories and monitoring efforts, so that further inferences may be drawn as to the effects of varied fire regimes and other factors, including storm surges.

COORDINATION WITH STATES
Indicate which State(s) (within the range of the species) provided information or comments on

the species or latest species assessment: The Service requested new information (observations, data, reports) regarding the status of this plant or any new information regarding threats to this species and its habitat from: Florida Department of Agriculture and Consumer Services, National Park Service, Service (National Wildlife Refuges), Florida Department of Environmental Protection, Miami-Dade County, Florida Fish and Wildlife Commission, FNAI, IRC, Historic Bok Sanctuary, The Nature Conservancy, FTBG, Archbold Biological Station, NatureServe, University of Central Florida, Florida International University, University of Florida, Princeton, members of the Rare Plant Task Force, botanists, and others. In total, a previous version of this assessment was sent to approximately 200 individuals.

The State of Florida does not specifically list plants in its State Wildlife Action Plan.

Indicate which State(s) did not provide any information or comments: Florida

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APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: _____ June 15, 2010
*for* Regional Director, Fish and Wildlife Service Date

Concur: _____ Date: October 22, 2010
ACTING
Director, Fish and Wildlife Service

Do not concur: _____ _____
Director, Fish and Wildlife Service Date

Director's Remarks:

Date of annual review: May 21, 2010
Conducted by: Paula Halupa, South Florida Ecological Services Office